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Suitability of Ohio Interstate Highway Borrow Pit Ponds for Sport Fishing

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CONTENTS

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ON THE COVER: Authors check a borrow pit fish population with a seine.

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SUITABILITY OF OHIO INTERSTATE HIGHWAY BORROW PIT PONDS FOR SPORT FISHING

STEPHEN H. TAUB, CLARENCE F. CLARK, DAVID A. MAYHEW, and JERRY B. LISIECKI[1]

INTRODUCTION

Providing quality sport fishing is an important concern in Ohio and other states. The state's population of 11 million is somewhat uniformly dispersed in the metropolitan complexes of Cleveland, Columbus, Cincinnati, Toledo, Akron, Dayton, and Youngstown. Unfortunately, the concentration of large lakes and impoundments is more prevalent in the northern portion of the state. This imbalance makes small ponds near Ohio's large cities an important component of sport fishery resources.

Interstate highway borrow pit ponds are located throughout the state, particularly near interchanges and cross routes, close to urban and suburban fishermen. Prior to this study, little was known about the potential of these ponds for sport fishing. Only Nebraska and Massachusetts have considered these ponds for long-term fishing benefits.

This study documented the number, surface acreage, and location of these ponds in Ohio. An intensive, 2½ year study of 11 ponds, selected at random by subsampling soil types, was made. Biological, chemical, and physical parameters were measured and evaluated. Construction costs were evaluated and physical enhancement features for sport fishing were identified and costs estimated.

As of July 1, 1970, Ohio had 211 interstate highway borrow pit ponds impounding 1,280 surface acres of water (exclusive of the Ohio Turnpike—Interstate 90). These ponds are primarily in private ownership and are poorly managed for sport fishing. They have limited watersheds and do not receive farmland runoff, resulting in less production than typical farm ponds. This situation can be corrected by careful fertilization. In most cases, better fish species management would enhance the ponds. Many existing ponds could be improved easily by reclamation of imbalanced fish populations and introduction of new ones. In some cases, this is not possible because of seasonal flooding and/or inlet-outlet streams. Some improvement features can be incorporated into existing ponds and a complete array of enhancement features can be incorporated into a new pond at a cost of about $4,200 per surface acre.

A detailed documentation of this study is contained in Clark *et al.* (4, 5, 6). Clark *et al.* (4) shows the location of the 11 study ponds by code numbers and a map.

PROCEDURES

Objectives

- To determine the number and estimated surface acreage of all interstate highway borrow pit ponds in Ohio.
- To select a random sample of study ponds, by soil types, for intensive study.
- To determine the ownership and present and future use plans of the study ponds.
- To evaluate the biological properties of the study ponds. Species composition, relative abundance, and inter-species relationships of aquatic organisms (especially fish) were determined.
- To determine the water quality and morphometry of the study ponds and to relate these factors to optimum standards for maximum fish production.
- To determine the methods of excavation used in forming the study ponds and to investigate construction methods which would improve the sport fishery potential of them.

Preliminary

The total number and surface acreage of all (except the Ohio Turnpike) interstate highway borrow pit ponds in Ohio were determined. These data were compiled from existing aerial photographs and on-site investigations. The Ohio Turnpike was excluded because of anticipated administrative problems and time commitments.

Selection of Intensive Study Ponds

Two ponds from each of Ohio's seven major soil types were originally intended to be randomly selected for intensive study. One of the major soil types was not crossed by an interstate route and another one had one pond; therefore, a total of 11 ponds were studied intensively (Figure 1) by major soil types (see Table 1 for physical parameters).

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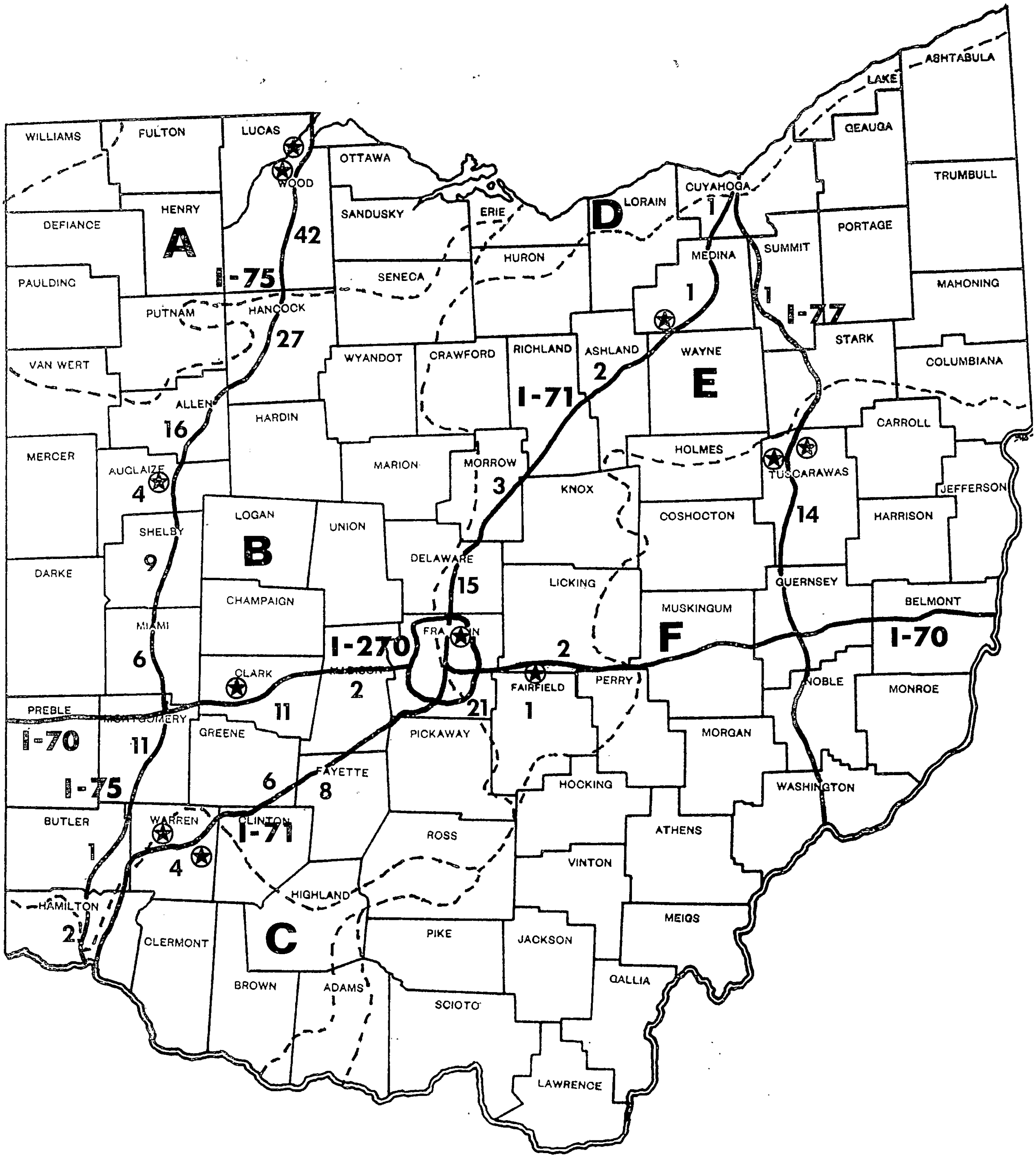


Large Numerals = Interstate Highways

Small Numerals = No. of Ponds in County

⊛ = Locations of 11 Study Ponds

------ = Soil Region Boundaries

Soil Regions:
A. Old Lake Bed
B. High-lime Wisconsin Till
C. Illinoian High-lime Till
D. Old Lake Bed Northeast
E. Low-lime Till
F. Sandstone and Shale Residual Soil

Fig. 1.—Ohio Interstate Highway Borrow Pit Ponds.

TABLE 1.—Physical Parameters of 11 Study Ponds.

	A		B		C		E(D)	E		F	
	75-1	75-11	72-44	70-9	71-1	71-3	71-2	270-3	70-2	77-3	77-7
Maximum length (feet)	869	2393	451	1450	1433	445	900	529	304	472	988
Maximum width (feet)	688	293	384	500	408	191	618	296	190	100	356
Mean width (feet)	435	186	248	295	356	154	402	218	137	99	220
Perimeter (feet)	2400	5520	1270	3200	3367	1121	2430	1365	805	1015	2175
Shore line development	1.10	2.33	1.07	1.38	1.33	1.21	1.14	1.14	1.11	1.40	1.32
Basin development	1.85	1.80	1.61	1.66	0.84	1.72	1.47	1.74	1.49	1.70	1.12
Surface area (acres)	8.67	10.23	2.56	9.82	11.71	1.57	8.31	2.64	0.96	1.08	4.98
Total volume (acre feet)	42.70	92.19	15.10	108.52	55.78	5.40	56.80	18.39	5.25	7.95	27.82
Mean depth (feet)	4.93	9.01	5.90	11.05	4.76	3.44	6.84	6.97	5.47	7.36	5.59
Maximum depth (feet)	8	15	11	20	17	6	14	12	11	13	15
Age (years)	4	4	13	7	8	8	13	3	4	9	9

Owner Use

The owners of the 11 intensive study ponds were personally interviewed with a prepared questionnaire. The questionnaire was used to determine the following statistics of the ponds: age, water source, ownership, cost to build, general use, and fishing.

Biological

Fish: Fish were captured during the 1970 and 1971 sampling seasons, using experimental gill nets, trap nets, bag seines, and angling. The number and total length of all fish captured were recorded. Scale samples for age and growth were taken from a representative subsample of the 1970 catch. Fish scales were read on an Eberbach projector and their age-growth at capture was compared to the Ohio average (15, 16) and the national average (2). Stomachs were removed and preserved in a 10% formalin solution from a representative subsample of the 1971 catch. The stomachs were analyzed for food habits according to the Points Method described by Hynes (7). Fish weight was calculated from Carlander (1, 2). The species composition and other vital statistics of the fish populations in each of the 11 intensively studied ponds are presented in this report.

Benthos: Ekman dredge samples were taken from shallow and deep areas in each of the 11 ponds in fall 1970 and spring, summer and fall 1971. All benthos samples were washed through standard sieves, sorted, and preserved in 10% formalin. Benthos organisms were identified and enumerated with a 30X dissecting microscope and weighed by water displacement.

Plankton: The plankton samples were obtained by taking a sample with a 3-liter Kemmerer bottle at 1-meter intervals from surface to bottom in two representative areas of each pond. The samples were concentrated in a plankton bucket (#25 plankton netting) to 25 ml. and preserved in 10% formalin. Samples were identified, and counted in a Sedgewick-Rafter counting cell under a binocular compound microscope at 125 and 288X (19).

Chemical-Physical

Maps for each of the 11 ponds were constructed earlier in the study (4).

Temperature and dissolved oxygen profiles were determined, using a YSI Model 54 oxygen and temperature probe.

Seasonal water chemistry analyses were measured using the Hach Chemical Kit, Model DR-EL.

Samples of anaerobic bottom sediments in six study ponds were taken with an Ekman dredge. Three sites on a transect over the deep area of each pond were used. The chemical and physical soil analyses were performed by The Ohio State University Department of Agronomy Soils Laboratory.

Biologist and Contractor Inquiry

An inquiry was sent to 21 fishery biologists in Ohio in an attempt to design an *ideal* borrow pit pond and to evaluate construction methods. Nine private contractors were also contacted to determine costs in building this ideal pond.

RESULTS

Owner Use Survey

All 11 questionnaires were returned and all were partially incomplete. Follow-up contacts were made and near-complete responses from all 11 owners were obtained.

Age: The oldest borrow pit ponds of the intensive study group were constructed in 1958; the most recent in 1968.

Water Source: In seven of eight cases, the construction companies had to pump water from the pit as their excavation progressed. The water in three came from underground springs, in two from rain exclusively, and in two from a combination of springs and rain. The length of time required for filling varied from 2 weeks in cases where underground springs were present to 2 years and still filling where rainwater was the only source.

Ownership: Six of the 11 ponds are still owned by the individuals who owned the land before borrow pit pond construction. Two of the ponds are owned by the companies which dug them after purchasing the land. Both companies are actively trying to sell their ponds. The other three ponds are now owned by new individuals who bought the land and pond from the construction companies.

Finances: The questions concerning financial arrangements for fill material were unanswered in most cases. In one case, the construction company dug the pond to landowner's specifications as payment for the fill material. In another case, the price was 5 cents per cubic yard, with 2,600 cubic yards sold. In three cases where acreage was sold to construction firms, the amount sold ranged from 10 to 15 acres, with one reported price of $3,500 per acre. The number of cases where fill material was sold equaled the number of acreage transactions. It appears that acreage transfer is the most common method of fill material acquisition.

General Use: Seven owners replied concerning general use history. Fishing was the most frequent use. Swimming, stock watering, boating, and irrigation followed in importance. The original land use of all ponds was in agriculture. Ten acreages were in crops and one was in pasture land.

Eight pond owners have never had professional advice on pond management. Six have never treated to kill noxious vegetation. One pond owner actively sought advice from the Hebron National Fish Hatchery on pond management, fertilization, and weed control. This owner and two others treat every spring with copper sulphate to control filamentous algae.

Six owners restrict use to those who have permission, and three of these further restrict use to family and close friends.

Fishing: Five owners replied concerning types of fishing and baits. On three ponds, shore and boat fishing are practiced, and shore fishing only on the remaining two. On all ponds, artificial baits are allowed, and on three ponds all types of baits, including minnows, are allowed. Four pond owners estimate an average of 17 anglers per week from May 15 through Sept. 15 and an average of 4 anglers per week from Sept. 16 through May 14 each year. All ponds receive an annual ice cover and ice fishing is allowed in four of eight cases.

Three of the pond owners stocked largemouth bass, sunfish, and catfish. In addition to these three species, pike were stocked in one pond and pike, perch, and trout in another. Four owners admit that anglers throw live fish into their ponds from other sources. In the seven ponds which have fish not stocked by the pond owners, angler introductions and flooding from nearby waters probably account for presence of the fish.

Four owners considered trespassing a problem. Two who did not were construction companies who may not be aware of this problem. One owner lived on the pond site, possibly deterring trespassing.

Seven ponds have a relatively stable water level which in at least six cases is influenced by underground springs. Three ponds were flooded by nearby streams during the statewide floods of the summer of 1969. However, normally the 11 ponds are not affected by flooding.

Fish Sampling

Tables 2-5 show total catch data by gear type and pond. Table 2 depicts total catch data which include all gear types. Because of the great variability in sampling and gear efficiency, especially with seines, gill and trap net catch data are presented separately in Tables 3, 4, and 5. The gill net/trap net index presented in Table 5 is especially useful in comparing the catch of the 11 ponds. The index is calculated by adding together the pounds per net hour values for gill and trap nets and averaging the added values for the two sampling seasons. This index combines the catch per effort data of two of the more standard gear types, and is the most reliable statistic available for use in fish catch comparisons among the 11 ponds.

Table 6 gives a species listing by family of fish captured during the study. Thirty-four species, representing nine families, were captured during the study. The sunfish family *Centrarchidae* had the largest representation with 10 species. Table 6 also gives the percentage by weight which each species made up of the total catch. Bluegill and largemouth bass made up 47% of the catch. Green sunfish and suckers were next in order of weight percentage abundance and constituted quite a problem in some of the ponds. Quite a few species are listed in trace quantities for the 11-pond total, but some were important in individual ponds. For instance, brook silversides were present in great numbers in one Tuscarawas County pond.

A total of 8,930 fish weighing 368 lb. were captured during the 2-year study. As shown in the tables, one of the 11 study ponds did not contain fish. The mean number of species per pond, of the 10 with fish, was 9.6, with a range of 3 to 21.

One method of comparing the fish populations of the study ponds is through analyses of comparative production. The combined 1970-71 gill net/trap net index (Table 5) is presented in Figure 2. The graph shows the great variability in this production index with a range of 0.00 to 0.92 lb. per net hour. Although the major soil types are shown (4), the great sensitivity of small pond fish populations to human manipulation precludes the validity of direct correlation of fish production indices by soil types. As an example, pond E-270-3 is relatively new and has never been stocked. Pond E-70-2 had only recently been stocked. These ponds exhibited low gill net/trap net indexes, but if stocked and allowed to develop to a more stable state, they might have much higher production index values.

The concept of fish population *balance* must be considered. Number and types of species present and relative abundance determine the population balance. The mean number of species in 10 borrow pit ponds containing fish was 9.6. This is much higher than the two or three species combinations used in scientific small pond fisheries management. Pond F-77-7 in Tuscarawas County had 21 species present during

TABLE 2.—Total Number and Weight of All Fish Caught by All Gear, 1970 and 1971.

	1970		1971		1970-71 Combined	
Pond	No.	Lb.	No.	Lb.	No.	Lb.
A-75-1 (Peirce)	4	0.43	1,263	16.02	1,267	16.45
A-75-11 (Voland)	92	8.72	245	18.23	337	26.95
F-77-7 (Spidell)	968	36.10	442	15.15	1,410	51.25
C-71-1 (Hauser)	382	25.11	387	14.00	769	39.11
B-70-9 (Goodfellow)	1,439	43.82	591	21.95	2,030	65.77
F-77-3 (Sohio)	172	12.96	55	8.52	227	21.50
E-70-2 (Senff)	208	4.12	167	4.44	375	8.56
E(D)-71-2 (Hanna)	230	20.60	225	15.34	455	35.94
C-71-3 (Henkle)	262	28.76	329	29.11	591	57.87
B-75-44 (Erb)	142	8.99	1,327	35.56	1,469	44.55
E-270-3 (Baltes)	No Fish Captured					
Total	3,899	189.61	5,031	178.34	8,930	367.95

TABLE 3.—Total Trap Net Catch, All Ponds, by Number and Weight by Gear Effort (Lb./Hour).

	1970		1971		1970-71 Combined	
Pond	No.	Lb./Net Hour	No.	Lb./Net Hour	No.	Lb./Net Hour
A-75-1	2	0.02	208	0.26	210	0.13
A-75-11	2	0.01	7	0.22	9	0.11
F-77-7	9	0.08	—	—	9	0.08
C-71-1	196	0.46	146	0.43	342	0.44
B-70-9	75	0.08	101	0.17	176	0.12
F-77-3	19	0.07	40	0.15	59	0.12
E-70-2	4	0.04	11	0.001	15	0.03
E(D)-71-2	21	0.11	64	0.21	85	0.17
C-71-3	—	—	4	0.01	4	0.01
B-75-44	29	0.15	72	0.60	101	0.36
E-270-3	0	0.00	0	0.00	0	0.00

TABLE 4.—Total Experimental Gill Net Catch, All Ponds, by Number and Weight by Gear Effort (Lb./Hour).

	1970		1971		1970-71 Combined	
Pond	No.	Lb./Net Hour	No.	Lb./Net Hour	No.	Lb./Net Hour
A-75-1	0	0.00	82	0.17	82	0.10
A-75-11	11	0.08	26	0.20	37	0.14
F-77-7	24	0.51	31	0.26	55	0.38
C-71-1	31	0.29	241	0.29	272	0.29
B-70-9	63	0.27	78	0.28	141	0.28
F-77-3	36	0.40	15	0.23	51	0.32
E-70-2	2	0.08	0	0.00	2	0.02
E(D)-71-2	49	0.32	82	0.18	131	0.23
C-71-3	70	1.11	97	0.72	167	0.92
B-75-44	13	0.15	39	0.34	52	0.27
E-270-3	0	0.00	0	0.00	0	0.00

TABLE 5—Total Catch, Gear* Combined, All Ponds, by Number and Weight by Gear Effort (Lb./Hour).

Pond	1970		1971		1970-71 Combined	
	No.	Lb./Net Hour	No.	Lb./Net Hour	No.	Lb./Net Hour
A-75-1	2	0.02	290	0.43	292	0.23
A-75-11	13	0.09	33	0.42	46	0.26
F-77-7	33	0.59	31	0.52	64	0.56
C-71-1	227	0.75	387	0.72	614	0.74
B-70-9	138	0.35	179	0.45	317	0.40
F-77-3	55	0.47	55	0.38	110	0.43
E-70-2	6	0.12	11	0.001	17	0.06
E(D)-71-2	70	0.43	146	0.39	216	0.41
C-71-3	70	1.11	101	0.73	171	0.92
B-75-44	42	0.30	111	0.94	153	0.62
E-270-3	0	0.00	0	0.00	0	0.00

*Trap nets and gill nets.

the study period. Many of these species were stream species and were introduced during the flooding of a nearby creek in 1969.

The presence of undesirable fish species can be detrimental to pond fish population balance. Significant numbers of fish such as gizzard shad, suckers, green sunfish, and bullheads were present in eight ponds. In several of the ponds, bluegill (normally a desirable pond species) were present in such large numbers that they almost completely dominated the fish fauna. All aspects of fish population inbalance were exhibited by at least several of the study ponds.

Production and balance must be considered together. The best fish-producing pond is C-71-3 as suggested by its 1970-71 gill net/trap net index of 0.92 lb. per net hour. However, approximately 90% of the total catch of C-71-3 consisted of rough species like white suckers; black redhorse, green and hybrid sunfish. Although this pond is the best fish producer, it is producing undesirable fish. Another example of the production-balance interaction involves pond E-70-2. This pond had a low gill net/trap net index of 0.06 lb. per net hour, but the population balance was good with a three-species composition of largemouth bass, bluegill, and channel catfish. This pond had only been stocked recently and any subsequent

TABLE 6.—Fish Species Encountered in 1970-71 Sampling, All Ponds, and Percentages by Weight of Total Catch by Species.

Species	Percent	Species	Percent
Centrarchidae		**Cyprinidae**	
Largemouth bass	11	Goldfish	trace
Smallmouth bass	trace	Carp	4
Bluegill	36	Golden shiner	1
Warmouth	trace	Bluntnose minnow	trace
Green sunfish	9	Southern redbelly dace	trace
Pumpkinseed	5	Redfin shiner	trace
Redear sunfish	trace	Spotfin shiner	trace
Sunfish fry	trace	Common shiner	trace
Hybrid sunfish	2	Sand shiner	trace
Rock bass	trace	**Catostomidae**	
White crappie	3	White sucker	11
Black crappie	trace	Black redhorse	2
Percichthyidae		Golden redhorse	trace
White bass	trace	Northern hog sucker	trace
Percidae		Quillback	trace
Yellow perch	trace	**Ictaluridae**	
Esocidae		Channel catfish	3
Northern pike	1	Black bullhead	4
Grass pickerel	trace	Brown bullhead	trace
Atherinidae		Yellow bullhead	2
Brook silverside	trace	**Clupeidae**	
		Gizzard shad	5

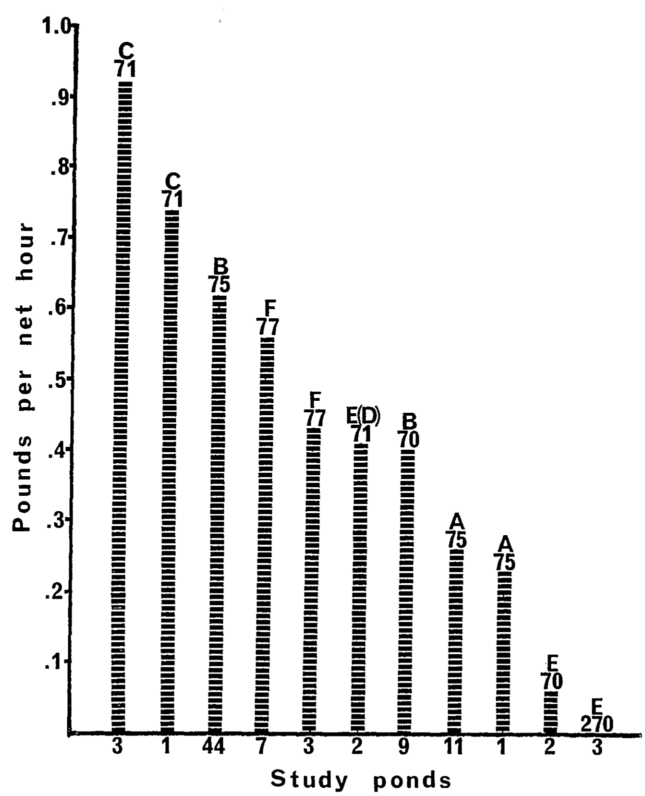


Fig. 2.—Gill/Trap Net Index, All Species Combined, by Weight and Soil Type.

sampling would most likely yield a much higher production index at a later time. Therefore, it is concluded that fish production in weight, desirable species, and establishment during a reasonable period of time are all criteria which must be met to evaluate successful production.

The 1970 and 1971 catch statistics for pond A-75-1 provide a dramatic example of the production potential of this pond. The 1970 sampling with seines, gill nets, and trap nets yielded four small sunfish. A similar fishing effort in 1971 yielded nearly 1300 fish, including northern pike, white bass, rock bass, green sunfish, and shiners. The latter, spawned in the pond earlier in the year, were present in great numbers. These fish represented a population explosion in a previously unexploited habitat and gave a more direct look at production potential than can be obtained through gear catch/effort indices. Minimal sampling effort could have influenced these results. However, the disparity from 1970 to 1971 is too great to attribute much of the variation to this, particularly since the fishing effort was similar in both years.

Another indication of the status of borrow pit pond fish populations is the presence or absence of successful reproduction of desirable species, such as largemouth bass. Although a concerted sampling effort was not directed at young bass, records from the normal sampling show recent year classes of largemouth bass in seven ponds.

Although some of the ponds exhibited a good fish production potential, nearly all of the ponds were unbalanced regarding fish populations. Only one pond was being reasonably managed for fish production during the study period. The general lack of intensive pond management was largely responsible for this. Mismanagement can be equally damaging, as suggested by erratic stocking policies, usually due to unintentional poor judgment by the owner. For example, one owner (pond A-75-11) stocked largemouth bass, pumpkinseed, channel catfish, yellow perch, northern pike, and rainbow trout. In other cases a reasonable initial stocking was made, but there was no continuous management. Fishermen and trespassers throw bait fish and larger fish captured in other waters into the pond, further complicating the situation.

Although the borrow pit pond fish populations in this study are at present unbalanced, the potential is present for these waters to support good sport fish populations with proper management.

Age-Growth Analyses

The results of the age-growth analyses are shown in Table 7. The figures in this table are mean total length of age groups at capture in late summer-fall 1970. In comparing these with the literature, the reader should note that literature values are usually back-calculated to annulus formation in the late spring. Therefore, in comparing the age-growth of

TABLE 7.—Mean Total Length (mm.) at Capture of Age Groups.

	Annuli						
Pond	**1**	**2**	**3**	**4**	**5**	**6**	**7**
				Bluegill			
Henkle (C-71-3)			112(5)*	130(5)			
Sohio (F-77-3)		103(1)	108(5)	119(4)			
Hauser (C-71-1)			100(2)	108(1)	155(2)		
Hanna (E(D)-71-2)				125(7)			
Senff (E-70-2)	53(2)	70(2)	149(3)	198(1)			
Erb (B-75-44)		102(2)	104(5)	127(23)	141(11)		
Spidell (F-77-7)		102(6)	124(16)	140(3)			
Goodfellow (B-70-9)	60(1)	80(9)	105(4)	119(7)			
				Pumpkinseed			
Henkle		89(4)	119(8)	128(6)			
Hanna			107(3)	116(2)			
Voland (A-75-11)			108(43)	114(12)			
				Green Sunfish			
Henkle			110(5)	118(9)			
Erb		76(2)	91(3)				
Voland			120(4)	118(1)			
				Largemouth Bass			
Hauser		170(1)	285(1)	372(1)		376(2)	
Senff		225(1)	235(9)				
Erb		164(6)					
Spidell		106(1)	224(3)	335(1)			430(1)

*Numbers in parentheses indicate number of fish.

fish in this study with the literature, it must be kept in mind that these fish had as much as one-half growing season gain vs. the literature for each respective age group. In considering the age-growth data of this study the small sample sizes of each species for each pond must be considered. Sufficient age-growth data were available to illustrate trends.

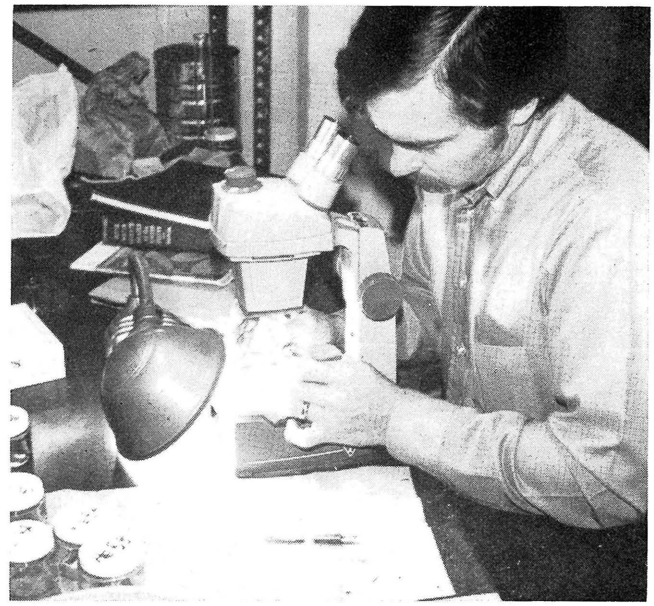
Roach and Evans (16) listed the mean total length (mm.) of bluegill for all Ohio lakes as 45 at 1st annulus, 92 at 2nd, 120 at 3rd, and 146 at 4th. In comparing their values with Table 7, and taking into account the preceding paragraph of this report, it was concluded that the study pond bluegills were growing at about an equal rate to the Ohio average. Similarly, Roach and Evans (15) list the following for largemouth bass: 95-1st, 180-2nd, 250-3rd, 368-4th, and 411-5th. The study pond largemouth bass growth about equaled the state average. There are no Ohio average figures for pumpkinseed and green sunfish.

A comparison of the age-growth rate of the four study species to their U. S. ranges in Carlander (1) was made (Tables 7 and 8). The age-growth rates of the study fish were about midway in the national ranges. However, some problems are inherent in making this generalization because these data were based on small sample sizes. Furthermore, in Carlander's compilation the ranges were wide and drawn from many extremes of fish growth conditions throughout the United States and foreign countries.

In conclusion, the bluegill, largemouth bass, pumpkinseed, and green sunfish age-growth rates of the study ponds were about average for Ohio and the United States. In many cases, newly established fish populations were being sampled. In spite of the shortcomings of the limited data of this aspect of the study, it is worth reporting. It is valid to reach these general conclusions of average growth rates for the study ponds.

Food Supply Variation

The quantity and quality of the food supply varied among the ponds. This was to be expected regardless of whether or not the ponds were of borrow pit or conventional farm type construction. Clark *et al.* (5) stated that borrow pit ponds have limited watersheds, the correct inference being that natural enrichment is usually more restricted. The data revealed that fish in the study ponds utilized the available food. The age-growth data supported this conclusion. There was no direct indication that the food supply, in terms of quantity or quality, was a limiting factor. However, a better balance of predator-prey fish (numbers and species) in almost all of the ponds would enhance the growth of desirable fish species.



David Mayhew checks fish stomachs to determine the use of available foods.

Five of the 11 ponds (B-75-44, C-71-3, E-70-2, E-270-3, and F-77-3) are at least seasonally connected to other waters. These are direct connections—inlets, outlets, and/or seasonal flooding. These physical characteristics result in an ingress and/or egress of the biota in the ponds. The value of this exchange to the food supply of the resident fish populations varies from being detrimental to beneficial. The assessment of this variable is difficult to measure, and was not done during this study except to note its occurrence.

Phytoplankton

Small green planktonic algae or phytoflagellates are considered beneficial to fish production in ponds. However, none of the borrow pit ponds had significant numbers of these types.

TABLE 8.—Size Range in Total Length (mm) at Annulus Formation in Carlander (1) by Fish Species.

	Annuli					
Species	1	2	3	4	5	6
Bluegill	13-165	65-192	102-226	116-268	125-273	126-305
Largemouth bass	63-330	150-432	178-470	190-483	226-559	226-571
Pumpkinseed	43- 89	56-152	71-157	66-206	102-231	119-229
Green sunfish	25-127	56-140	71-216	86-157	117-185	132-185

The highest phytoplankton levels in the study ponds were caused by blue-green or Cyanophyta algae. Ponds A-75-11, E-70-2, and F-77-3 had moderate concentrations of blue-greens (*Microcystis* sp., *Anabaena* sp., and *Oscillatoria* sp., respectively). Pond B-75-44 had the most phytoplankton concentration in summer and fall and in the mean for all three seasons. The pond had increasing concentrations of *Microcystis* in each subsequent sampling period, with a value of 5.5 million cells per liter in fall 1971. This is definitely *heavy bloom* proportions. The high levels of blue-green algae and few species present are indicators of productive water.

Dinobryon sp. occurred in moderate numbers in several of the ponds in spring, and reached nearly 1 million cells per liter in spring and summer in pond F-77-3. *Dinobryon* is a colder water form and usually disappears as the water mass warms. This genus is not considered an indicator of productive water.

The previously mentioned variability of fish populations in small ponds, the difficulty of monitoring chemical nutrients, and the sampling frequency necessitated in this state-wide project precluded extensive correlation of phytoplankton levels with fish production indices and other biological and chemical parameters. However, some general relationships were apparent. For example, pond B-75-44, with a mean of 3 million cells per liter (highest of all ponds), ranked third in the fish production index and second in mean zooplankton levels. Only one other pond, F-77-3, might be classed as productive on the basis of its mean production level (800,000 cells/l.). This pond was second in phytoplankton production, and first in zooplankton production.

Only two ponds, B-75-44 and F-77-3, could be classed as very productive at this time on the basis of phytoplankton levels.

Zooplankton and Benthos

Mean standing crop data are presented for two zooplankton groups in Table 9. The adult copepods and cladocerans are grouped together because of their importance as fish forage. Mean total zooplankton values are given as an index to total zooplankton production. There is not necessarily any correlation between the two groups.

The two highest zooplankton producers, ponds B-75-44 and F-77-3, are also the highest phytoplankton producers. The higher total zooplankton producers are generally among the higher fish-producing ponds. Again, sampling frequency and human manipulation of the fish populations prohibited any attempt at more involved correlations.

Few of the ponds had large populations of copepods and cladocerans. The highest levels of these

TABLE 9.—Zooplankton, Average of Three Sampling Seasons (1971) in Organisms per Liter.

Pond	Adult Copepods and Cladocerans	All Zooplankton
A-75-1	14	210
A-75-11	40	188
B-75-44	245	1,936
B-70-9	144	241
C-71-1	59	1,230
C-71-3	379	1,769
E(D)-71-2	117	1,131
E-270-3	41	87
E-70-2	20	1,379
F-77-3	40	2,350
F-77-7	65	753

groups were found in ponds B-75-44 and C-71-3 (Table 9). This, with total zooplankton, phytoplankton, and gill net/trap net index, suggests the greater productivity of these two ponds. The levels of copepods found in all ponds were not unusual, at most being a couple hundred individuals per liter. Levels of 1,000 individuals per liter have been reported in some studies (11). Number of cladocerans of 200 to 500 per liter are reported as exceptional by Pennak (11). Only two ponds had levels of cladocerans above 200/l. at any time. Pond B-75-44 had 495/l. in fall and C-71-3 had 940/l. in summer. These are exceptional levels of cladocerans.

The very high rotifera population, in excess of 1,000/1. is considered unusual (11). In contrast to the situation with the crustacean zooplankters, six of the study ponds had rotifers in excess of 1,000/l. during at least one of the sampling periods. Pond F-77-3 had rotifers in excess of 4,000/l. during the summer sampling period. Among these ponds are those which are also highest in fish and phytoplankton production.

Table 10 shows the presence or absence of the various taxa of benthic macroinvertebrates from the 11 ponds. Included are data from both Ekman dredge and Hester-Dendy multiplate samples. The data represent a qualitative evaluation, but point out the importance of certain groups, particularly immature insects of the order Diptera, in pond bottom communities.

Table 11 lists the mean number of benthic organisms per square meter (m.^{2}) for each pond over the three sampling seasons. The sampling design was insufficient to permit species by species analyses on a per square meter basis. However, the mean numbers of benthic organisms/m.^{2} point out the same general trends as have the other biological and chemical indices. Ponds B-75-44, C-71-3, and F-77-3, shown to be more productive on the basis of other data, have approximately 3,000-5,000 organisms/m.^{2}. The greatest average value for any pond was 11,051

TABLE 10.—Species Diversity of Benthic Macroinvertebrates by Pond.

	A		B		C		E(D)	E		F	
Species	**75-1**	**75-11**	**75-44**	**70-9**	**71-1**	**71-3**	**71-2**	**270-3**	**70-2**	**77-3**	**77-7**
INSECTA											
Chironomidae larvae	X*	X	X	X	X	X	X	X	X	X	X
Chironomidae pupae			X	X		X	X		X		X
Palpomyia sp.	X	X	X	X	X	X	X	X	X		
Culicoides sp.							X				
Chaoborus sp.	X	X	X	X	X	X	X	X	X	X	X
Berosus sp.	X							X			
Haliplus sp.	X								X		
Dubiraphia sp.		X									
Anisoptera			X	X	X	X			X		
Zygoptera	X	X	X	X		X	X	X	X		
Caenis sp.	X	X	X	X		X	X		X	X	
Stenonema sp.				X							
Leptohyphes sp.		X									
Hexagenia sp.		X	X								
Polycentropus sp.							X				
Oryethira sp.						X					
Leptocella sp.			X								
Triaenodes sp.									X		
AMPHIPODA											
Hyallella azteca	X	X					X				
COPEPODA											
Harpacticoida	X		X	X	X	X	X			X	X
TURBELLARIA											
Dugesia sp.			X							X	
OLIGOCHAETA		X	X	X	X	X	X		X		X
HIRUDINEA							X				
GASTROPODA											
Physa sp.	X	X	X		X	X	X	X	X		X
Stagnicola sp.	X										
Somatogyrus sp.						X					
Amnicola sp.	X	X				X					X
Helisoma sp.						X					
Gyraulus sp.	X				X	X					
PELECYPODA											
Anodonta grandis							X				

*Denotes presence in at least one seasonal sample.

organisms/m.^{2} (pond E-70-2). This figure is influenced mainly by the large number (approximately 30,000/m.^{2}) of phantom midge *(Chaoborus* sp.) larvae present in spring 1971.

TABLE 11.—Average Number of Benthic Organisms per Square Meter for All Seasons.

Pond	Square Meters
A-75-1	941
A-75-11	1,477
B-75-44	5,531
B-70-9	152
C-71-1	5,764
C-71-3	3,586
E(D)-71-2	978
E-270-3	1,228
E-70-2	11,051
F-77-3	2,942
F-77-7	1,928

Because of the complexity of factors affecting production of benthic organisms, attempts at characterizing the study ponds on the basis of benthos standing crops were not advisable. More intensive sampling programs are needed before any such attempt can be made with resultant reliable conclusions.

Aquatic Plants

Table 12 lists higher aquatic plant species found in the study ponds. Aquatic species are presented with a general scale of abundance, while the shore and emergent species are listed as present or absent. The early invasion species in these ponds, means of seed dispersal, and other problems are under study by The Ohio State University Herbarium personnel.

Aquatic species which are quick to invade newly disturbed aquatic habitats include *Potamogeton foliosus, P. nodosus, P. pectinatus,* and *Myriophyllum exal-*

TABLE 12.—Occurrence and Abundance of Aquatic Macrophytes.

	Pond										
	A		B		C		E(D)	E		F	
Macrophyte	75-1	75-11	75-44	70-9	71-1	71-3	71-2	270-3	70-2	77-3	77-7
Potamogeton pusillus								2*	2		
Potamogeton foliosus	2	1	1			1		1			1
Potamogeton pectinatus	3									1	1
Potamogeton nodosus							1		1		
Potamogeton subsection pussilii		1		1							
Najas minor							2				
Najas flexilis			1				1				
Najas guadalupensis					1						
Myriophyllum exalbescens					3				2		
Salix interior					X	X	X				
Juncus torreyi	X						X				
Juncus effusus							X	X			
Juncus nodosus								X			
Typha latifolia			X		X		X		X		
Typha angustifolia			X		X		X				
Typha sp. immature	X					X		X			
Scirpus atrovirens					X	X			X		
Scirpus polyphyllus									X		
Eleocharis obtusa						X	X		X		
Eleocharis smallii			X								
Alisma Plantagoaquatica									X		
Carex lurida							X				
Carex sp.									X		
Sagittaria rigida	X										
Polygonum persicaria								X			
Sparganium sp.								X			

*1=not abundant, 2=moderately abundant, 3=abundant, X=present.

bescens (Hynes, personal communication). One or more of these speices occurred in 10 of the ponds.

The aquatic species in Table 12 are generally tolerant of turbidity. Two species, *Potamogeton pusillus* and *Najas flexilis,* are reported rare in Ohio (17).

Aquatic macrophytes in ponds and lakes are very beneficial as fish nurseries, food producing substrates, and oxygen producers. Although the absence of macrophytes is not necessarily harmful, an overabundance usually is. At least three of the ponds (Table 12) had macrophyte beds extensive enough to shelter young fish to the extent that sunfish were becoming overabundant. In this respect, macrophytes directly affected fish production balance.

Oxygen Depletion and Thermal Stratification

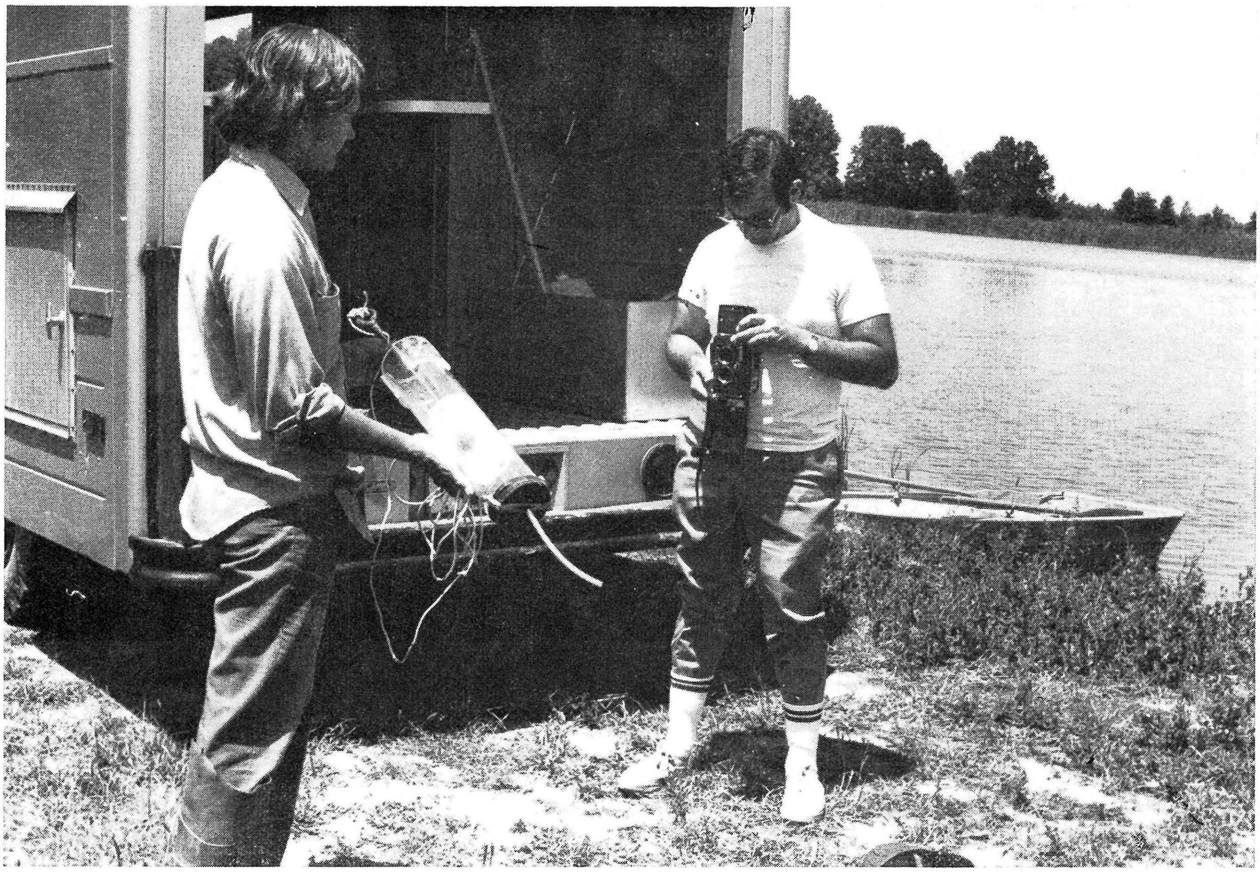
In general, the ponds were in some stage of complete mixing during the spring and fall measurements, and thermally and chemically stratified during summer (see Appendix). Specifically, nine ponds were thermally stratified during July 1971. The two ponds not thermally stratified at that time were relatively shallow (maximum depths 6 and 8 ft.) and easily mixed by wind action. Some of the ponds were thermally stratified in spring and fall, but this is usually not as important as summer stratification with its accompanying oxygen depletion in the hypolimnion.

Nine ponds exhibited hypolimnion oxygen levels insufficient to support fish in July. One pond, E-270-3, was thermally stratified but had sufficient oxygen in all levels in July. This pond was the newest of the study ponds, and had not had time to develop a sedimental and biotic respiratory demand large enough to cause oxygen depletion. Pond A-75-1 was shallow and easily wind mixed, and therefore remained oxygenated at the bottom during summer.

Pond C-71-3 showed no thermal stratification in summer, probably due to its shallow, easily mixed waters. However, the lower one-fourth of the water column was oxygen deficient in July. This is one of the more productive ponds and a large respiratory demand depletes lower layers of oxygen despite the lack of thermal stratification.

Water Chemistry

Comparison of surface and bottom water measurements for summer clearly shows the presence of chemical stratification in nine ponds. This was due to lack of circulation and absence of oxidation in the bottom waters.



Stephen Taub takes a picture of David Mayhew and equipment for sampling water in layers.

The productivity of the ponds was not limited by carbonate content. Ten ponds exhibited total alkalinity values above 40 p.p.m. in surface waters during the study. This is a hard water classification according to Moyle (10), and represents generally greater productivity in respect to carbonate concentration. Pond A-75-1 had a total alkalinity of 30 p.p.m. in summer but higher in fall and spring. This pond was borderline with respect to carbonate hardness.

Moyle (10) also classed Minnesota lake waters on the basis of combined sulfate and carbonate content. On this basis, 10 ponds ranged from hard to alkaline. Pond A-75-1 was lowest in total alkalinity (30 p.p.m., summer), but second highest in sulfate ion concentration (400 p.p.m.). In general, the potential biological productivity of these ponds should not be limited by carbonate and sulfate concentration.

Optimum fish production in Minnesota rearing ponds was obtained with total phosphate concentrations between 0.11 and 0.20 p.p.m. Ponds B-75-44, F-77-3, and F-77-7 exhibited values in this range at least once during the study period. Pond B-75-44 sustained the largest phytoplankton populations during summer and fall. Some of the ponds showed total phosphate values below 0.05 p.p.m. This is in the low to fair phosphate productivity range of Moyle (10). Therefore, some of the ponds may be phosphate-limited at certain times. The sensitivity of the method and the seasonal fluctuation of total phosphate values prohibit definite statements concerning the limiting nature of the measured values for the ponds.

Reid (14) gives a world-wide average nitrate nitrogen concentration of 0.3 p.p.m. for unpolluted fresh waters. Rawson (12), quoted in Clark (3), gives a maximum value of 0.1 p.p.m. nitrate nitrogen for natural waters. Seven study ponds had nitrate nitrogen concentrations in surface waters above 0.1 p.p.m. during at least one sampling period. Ponds B-75-44 and F-77-3 had nitrate nitrogen values above 0.3 p.p.m. during each of the three seasonal sampling periods. Highest recorded values were 3.74 and 2.55 p.p.m. for B-75-44 and F-77-3, respectively, during July 1971. These two ponds ranked high in biological productivity (4), and the high levels of nitrate nitrogen, an important inorganic nutrient, undoubtedly had some effect on this productivity.

Only pond B-75-44 had significant levels of nitrate nitrogen during the study period, 0.16 p.p.m. in July 1971. This is significantly above the 0.05

p.p.m. Rawson (12) gives as a maximum for natural waters, and again points out the enriched condition of this pond.

Both ponds B-75-44 and F-77-3 were unusual in that they had direct connection to external water sources. Pond F-77-3 had a 200-foot water-filled channel connecting it directly with the enriched Tuscarawas River. Pond B-75-44 had a permanent inflow at one point coming from a culvert.

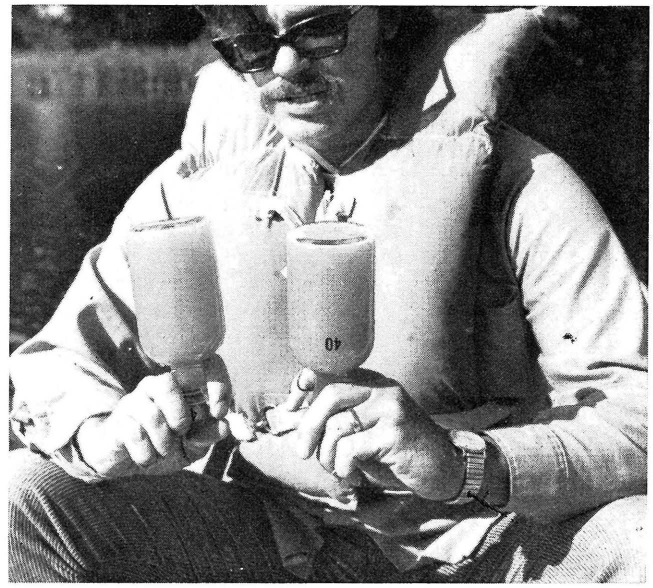
The enriched condition of these two ponds, in respect to inorganic nitrogen and their generally higher biological productivity, illustrates an important point. The average borrow pit pond in Ohio is an isolated system. It has no inflow, and thus no watershed from which to draw important nutrients. This is the basic difference between borrow pit ponds and other pond systems such as farm ponds and small on-stream impoundments. Ponds B-75-44 and F-77-3 are exceptional in that they do have watersheds. The watersheds in these cases are artificial, but serve the same functions.

The chemical data show a wide variation. As discussed above, some of the higher concentrations of certain nutrients probably aided in bringing about greater fish, benthos, and plankton standing crops in these ponds. However, it is doubtful that any important chemical material is absent, or present in such limiting quantities, as to prohibit the development of any of the ponds into successful sport fishing lakes.

Selected chemical and physical soil parameters can be found in Lisiecki (8). The samples were all anaerobic as six ponds were stratified and had anoxic bottom waters at the sampling times. It is difficult to relate these data to biological productivity due to the small sample size and the fact that the sediment area was unavailable and not utilized by most members of the biotic community because of the anaerobic condition (8).

Of the sediment sample ponds, C-71-1 and E (D)-71-2 had no calcium compounds present in the bottom. This may have had an effect on biological productivity. However, a more intensive sampling scheme directed at sediment and benthos interrelationships would be needed (8).

One clear point brought out by the sediment analyses is the general low level of organic matter present (8). Pond B-75-44, shown to be one of the most productive ponds on the basis of water chemical nutrient levels and biological standing crops, had the highest level of organic carbon present with 2.23%. However, the range of values for organic carbon for the six ponds was lower than values found from similar analyses for other water bodies reported in the literature (8). The accumulation of organic matter appears to be a slow process in the borrow pit ponds, and may be related to the general lack of a watershed or other external source of organic material and other nutrients. A program of fertilization might be a valid part of the fish management program for some ponds.



Duplicate water samples were thoroughly mixed during their analyses.

Evaluation of Construction Methods and Costs

An *ideal* borrow pit pond of 6 surface acres (Ohio's interstate borrow pit pond average) was designed. A map and a set of general specifications were prepared. The specifications for the purpose of hypothetical bidding by actual contractors were:

- Pond to be constructed according to attached map. Assume that the soil type is dirt and that fill is needed to construct an overpass 1,000 feet away.
- Side slopes shall be 3:1.
- Riprap shall be of large stone, in the location shown on the map, and extend below the water surface to the 3-foot contour interval.
- Islands shall be retained and riprapped as shown.
- Spawning devices are to be placed where shown, and shall consist of a 6-inch layer of pea-size washed gravel covered with two inches of clean sand. Each spawning device is to measure 10 x 40 feet, with the long axis facing north-south, and placed 10 feet from the shoreline.

This pond design (Figure 3) was a composite based on an inquiry sent to 21 state, federal, and university fishery biologists in Ohio. The inquiry was purposely flexible, and asked them to list and sketch the physical specifications of their idea of an *ideal* man-made pond for sport fish production in Ohio. Fourteen replies were returned, of which 13 were received in time to incorporate in the composite.

The 13 respondents enclosed a map and commented on four major areas of fishery improvement in the physical design. These were shape, slope, depth, and spawning devices.

Shape: Six respondents suggested irregular shape (assymmetrical with coves) and two suggested regular shape. The main reasons given for irregular shape were more diverse fishery habitat with greater shoreline development, more prime fishing water provided to shore fishermen, and aesthetics.

The two respondents preferring regular shape reasoned this would facilitate standard management practices such as test netting and reclamation.

Slope: Eleven replies commented on slope. The range of suggested slope ratios was 1:1.25 to 1:4.0. Several persons suggested combination slopes in different parts of the pond. Most respondents suggested a 3:1 slope.

Depth: Eleven replies discussed maximum and average depths. There was almost near unanimous agreement that a maximum depth of 15 ft. would be optimum. Several pointed out that if greater water depths were planned, thermal stratification would probably occur in the summer, with concurrent limited production potential in the hypolimnion. Most replies agreed it would be best to avoid depths less than 3.0 ft. since aquatic weeds would result in overprotection of young forage fish.

Spawning devices: Seven respondents expressed a desire to have several gravel-sand spawning substrate plots near the shoreline.

Between Dec. 1971 and July 1972, a total of nine private contractors in central Ohio were suggested by the Franklin Co., Ohio, Office of the Soil Conservation Service, U. S. Dept. of Agriculture. These contractors were contacted and provided with plans and specifications. Three of the nine furnished price estimates on additional costs to build the *ideal* pond.

Planimetry of the ideal pond revealed that 65,000 cu. yd. of fill would have to be removed to construct the pond. There are some readily apparent difficulties inherent in asking contractors to price estimate the excavation of a hypothetical pond this way vs. their normal way. Regardless of the method, prices will vary greatly depending upon the contractor's need for the fill material. At one extreme, in Central Ohio if fill is needed and it is of good quality and close to the fill need site, the contractor will pay the landowner 5-10 cents per cu. yd., then subtract monies depending upon the extent of special modifications the landowner wants. In two situations, contractors wanted large amounts of fill, it was very close to the overpass site, and the property owners were paid well for the dirt and had desired ponds built in addition. On the other hand, if the fill is not needed, is of low quality, and a long distance from the contractor's need, the landowner can expect to pay $1.00 to $1.25 per cu. yd. for having the fill removed and hauled away. Several fill haulers mentioned that their prices are governed by such factors as the number of traffic lights on the route.

Most situations in interstate highway construction would be some compromise of these extremes. In Michigan and West Virginia, the state purchases the cut sites along the construction route. However, in Ohio, highway construction contractors usually negotiate with landowners for their fill needs. In Franklin County, Ohio, the method of extraction and final dress now have to meet rigid requirements.

The main construction equipment used in excavating borrow pit ponds is the Pan Scraper. These machines have capacities as great as 30 cu. yd., self loading, compared to 2-3 cu. yd., manual, of 10-15 years ago.

Approximately 703,000 cu. yd. of fill were removed from the 11 intensive study ponds. This material had an average 1971 cash value of approximately $35,150 (at $0.05/cu. yd.) However, this figure is subject to wide variation.

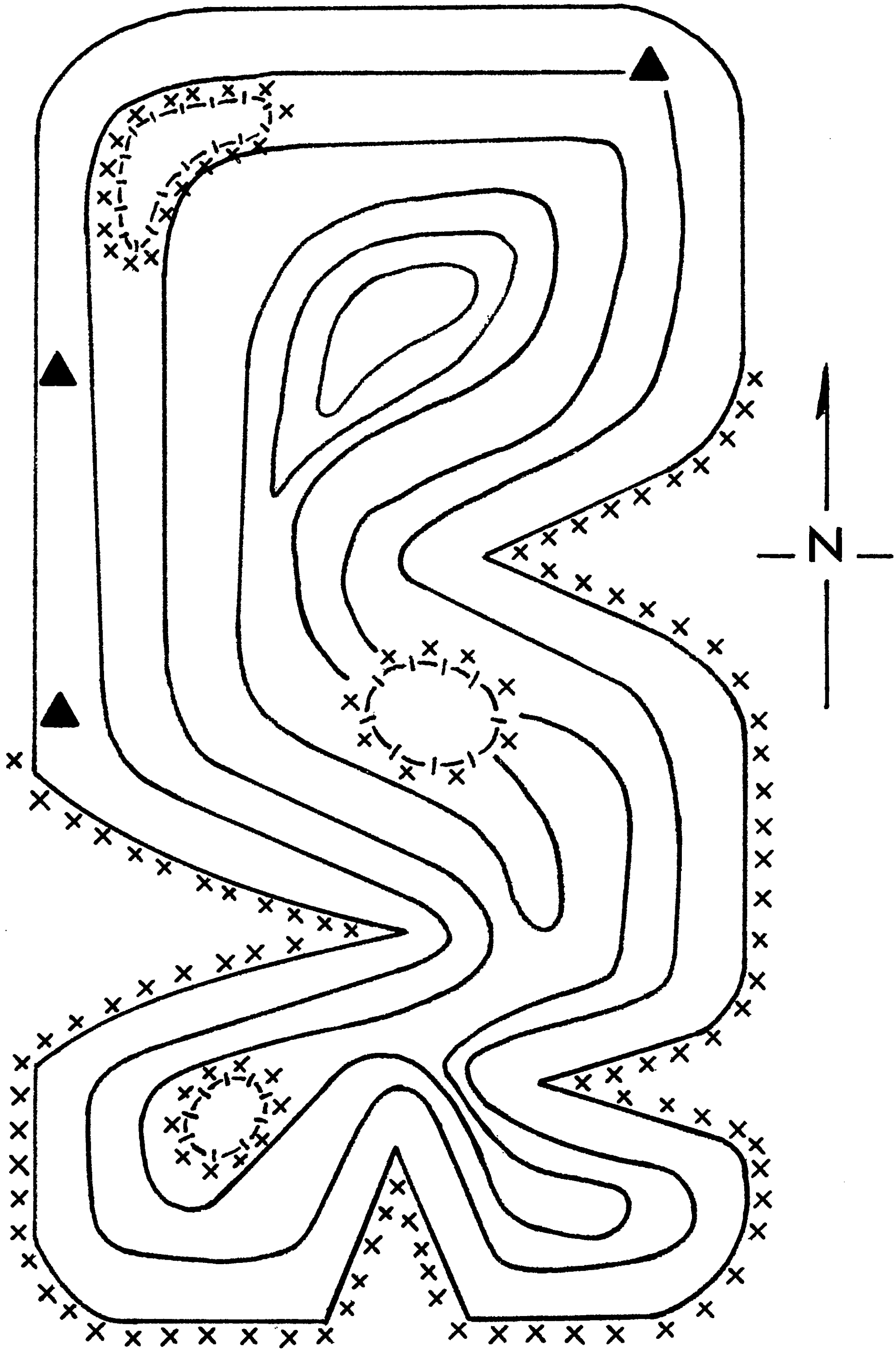
There was variation among the contractors for each sub-cost of the total (Table 13). However, the mean of the totals ($25,166) is only 12% lower than the high figure. Similarly, the mean is 10% higher than the low figure.

It is difficult to consider this aspect in generalities. Each situation has its own particular economic considerations. The primary cost factors are need, quality, and proximity of fill to the construction site. At one extreme, an owner paid $1.00/cu. yd. to have a pond dug and the excavated fill removed. This cost hypothetically projected to the 65,000 cu. yd. ideal pond would cost an owner $65,000. At the other extreme, a central Ohio farmer received $16,000 for his fill and had a pond made to his specifications.

TABLE 13—Estimates of Three Contractors for Additional Costs for Early to Mid-1972 in Central Ohio.

	Contractor		
	A	B	C
Earthmoving	$ 8,750.00	$13,000.00	$16,250.00
Riprap*	13,500.00	15,000.00	7,000.00
Spawning areas	250.00	500.00	500.00
Total	$22,500.00	$28,500.00	$24,500.00

*Assume for the purpose of Figure 3 that riprap is on the windswept shore only.



1" = 100'

contour interval = 3'

-- island

XXX -- riprap

▲ -- spawning device

Fig. 3.—Ideal Borrow Pit Pond.

In this instance, the fill was needed for an overpass less than 500 feet away and was of high quality.

Future interstate highway borrow pit ponds can be constructed to enhance sport fishery values at a cost which is feasible. Unfortunately for this consideration, the Ohio Interstate System is nearly completed.

It is probably not feasible to incorporate major physical enhancements into existing ponds at this time. Changing slope, shoreline, bottom contours, and adding riprap and islands to an existing, water-filled borrow pond would be cost prohibitive. Predictions cannot be made when fishing pressure will be great enough to warrant major construction enhancements to an existing borrow pond. However, other management practices such as fertilization, spawning devices, and species management could easily be incorporated in existing ponds where needed (5).

New borrow pond sites in Ohio and other states should be given consideration for sport fishery enhancement. Regardless of public or private ownership or whether roads are interstate or secondary well traveled routes, ponds will continue to be of greater importance for fishing. Tharp (18) reports that by the year 2000, the U. S. population is expected to increase 98% over the 1960 figure and that fishermen are expected to increase 150% during this same 40-year period. He says the need to meet this fishing demand can be best achieved by adding new waters and better managing existing ones.

The cost to incorporate enhancement features at the start of construction is less than $5,000/surface acre. These costs amortized during the life of a pond are minimal in consideration of the benefits gained.

No references exactly applicable to physical requirements for small warm-water fishery ponds could be found. Rawson and Ruttan (13), discussing trout requirements in Saskatchewan ponds, found water depth was the most single important criterion. Depths greater than 15 ft. were essential to alleviate winter-kill. McCrimmon (9), in his review of trout ponds in southern Ontario, found that ponds greater than 2.0 surface acres were more prone to aquatic weed and coarse fish problems than smaller ponds. He recommended depths of greater than 15 ft. in non-flow-through ponds to prevent winter-kill.

CONCLUSIONS

Ohio's 211 interstate highway borrow pit ponds (exclusive of I-90), representing 1% of Ohio's standing water, are concentrated in the flatter portions of the state. They are located near interchanges, close to human population centers, and represent an existing or potential source of quality fishing waters with proper management. These interstate ponds will become increasingly important in providing fishing for the angling public. Most of these ponds are now in private ownership. A growing number, however, have come into public ownership through acquisition by local municipalities.

Results of an intensive survey of 11 ponds reveal these ponds are neglected in terms of management for sport fishing. Approximately one-half of the ponds are seasonally connected with other waters through flooding or inlet-outlet streams. This physical characteristic results in the interchange of biota between the ponds and connecting waters. Generally, this is undesirable because it results in too many species and concurrent over-competition in the ponds. In some cases it is desirable because it provides enrichment. Better fish species management is a reasonably simple technique which would greatly enhance the quality of sport fishing. This can be accomplished where physical features do not preclude it and the desire of the owner for that purpose is strong.

These ponds have limited watersheds. They are less fertile than typical farm ponds draining agricultural lands. Production is lower in borrow pit ponds, but could be improved through a careful plan of fertilization at moderate expense.

Optimum physical enhancement features for sport fishing can be incorporated into a new borrow pit pond for an additional cost of about $4,200/acre. This cost becomes minimal when amortized over the life of a pond, and will appear considerably lower in terms of the value of these recreation sites in the year 2000. Some enhancement features can be incorporated in existing ponds.

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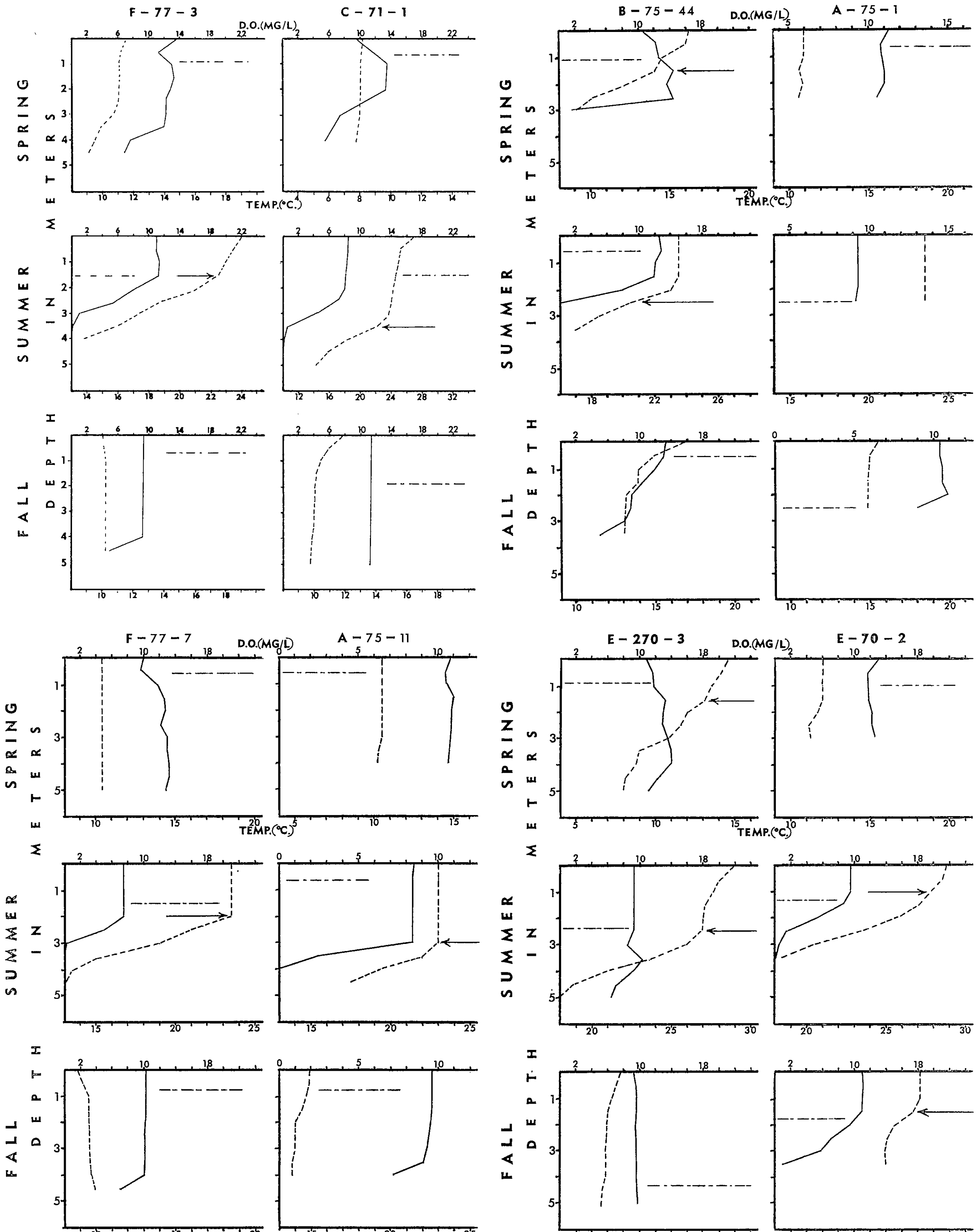
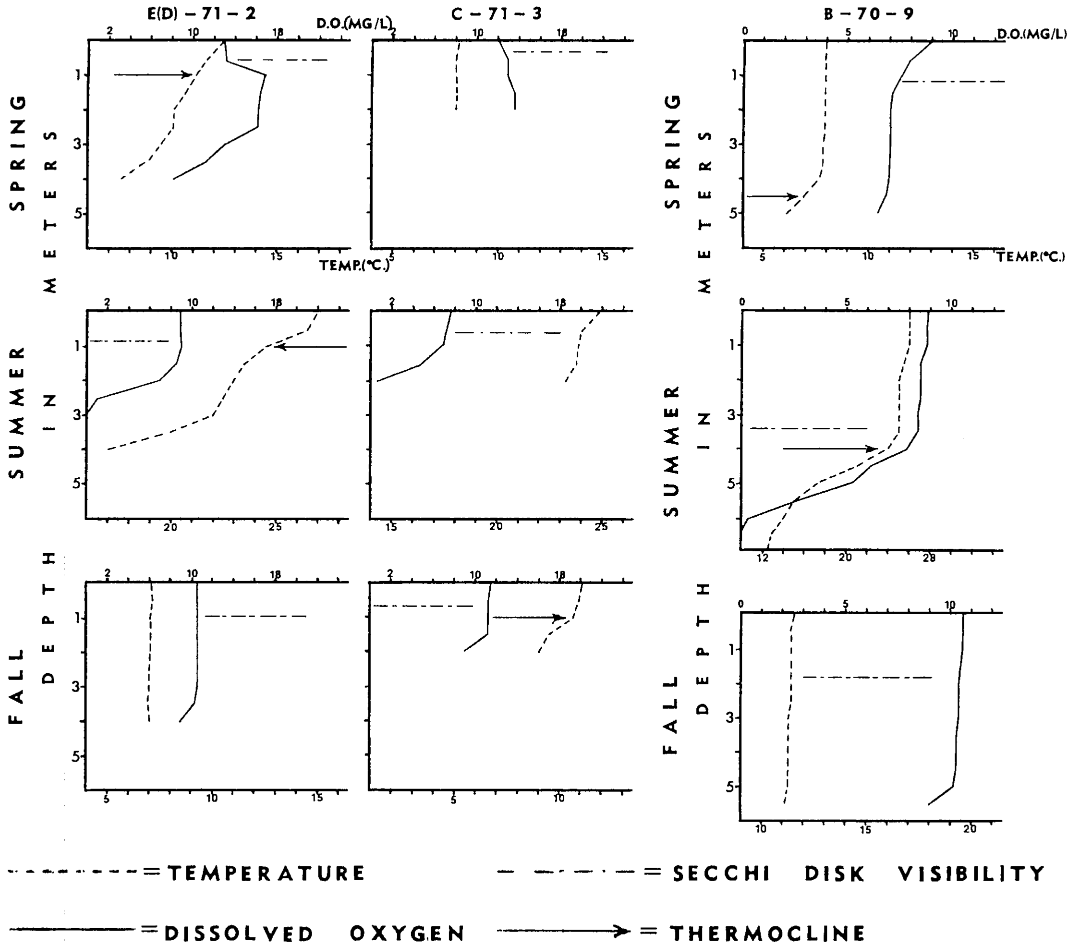
APPENDIX—Dissolved Oxygen and Temperature Profiles of the 11 Study Ponds.



- - - - - = TEMPERATURE — · — · — = SECCHI DISK VISIBILITY

——— = DISSOLVED OXYGEN ———> = THERMOCLINE



E(D) – 71 – 2
C – 71 – 3
B – 70 – 9
D.O.(MG/L)
TEMP.(°C.)
SPRING
SUMMER
FALL
METERS IN DEPTH
--------- = TEMPERATURE
— —·—·— = SECCHI DISK VISIBILITY
——— = DISSOLVED OXYGEN
———> = THERMOCLINE

BETTER LIVING IS THE PRODUCT

of research at the Ohio Agricultural Research and Development Center. All Ohioans benefit from this product.

Ohio's 110,000 farm families benefit from the results of agricultural research translated into increased earnings and improved living conditions. So do the families of the thousands of workers employed in the firms making up the state's $8 billion agribusiness complex.

But the greatest benefits of agricultural research flow to the millions of Ohio consumers. They enjoy the end products of agricultural science—the world's most wholesome and nutritious food, attractive lawns, beautiful ornamental plants, and hundreds of consumer products containing ingredients originating on the farm, in the greenhouse and nursery, or in the forest.

The Ohio Agricultural Experiment Station, as the Center was called for 83 years, was established at The Ohio State University, Columbus, in 1882. Ten years later, the Station was moved to its present location in Wayne County. In 1965, the Ohio General Assembly passed legislation changing the name to Ohio Agricultural Research and Development Center—a name which more accurately reflects the nature and scope of the Center's research program today.

Research at OARDC deals with the improvement of all agricultural production and marketing practices. It is concerned with the development of an agricultural product from germination of a seed or development of an embryo through to the consumer's dinner table. It is directed at improved human nutrition, family and child development, home management, and all other aspects of family life. It is geared to enhancing and preserving the quality of our environment.

Individuals and groups are welcome to visit the OARDC, to enjoy the attractive buildings, grounds, and arboretum, and to observe first hand research aimed at the goal of Better Living for All Ohioans!

The State Is the Campus for Agricultural Research and Development

Ohio's major soil types and climatic conditions are represented at the Research Center's 13 locations. Thus, Center scientists can make field tests under conditions similar to those encountered by Ohio farmers.

Research is conducted by 15 departments on more than 6500 acres at Center headquarters in Wooster, nine branches, Green Springs Crops Research Unit, Pomerene Forest Laboratory, and The Ohio State University.

Center Headquarters, Wooster, Wayne County: 1953 acres

Eastern Ohio Resource Development Center, Caldwell, Noble County: 2053 acres

Green Springs Crops Research Unit, Green Springs, Sandusky County: 26 acres

Jackson Branch, Jackson, Jackson County: 344 acres

Mahoning County Farm, Canfield: 275 acres

Muck Crops Branch, Willard, Huron County: 15 acres

North Central Branch, Vickery, Erie County: 335 acres

Northwestern Branch, Hoytville, Wood County: 247 acres

Pomerene Forest, Laboratory, Keene Township, Coshocton County: 227 acres

Southeastern Branch, Carpenter, Meigs County: 330 acres

Southern Branch, Ripley, Brown County: 275 acres

Western Branch, South Charleston, Clark County: 428 acres